A SYSTEMS ANALYTIC APPROACH TO THE ESTIMATION OF FUTURE MILITARY NEEDS.

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THESIS

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ABSTRACT

A systems analysis of the processes involved in the estimation of future military needs is presented. A conceptual model of the estimation procedure is formulated and illustrated. Several applicable methods are examined in the context of practical approaches to the needs estimation problem. These methods are then evaluated in the framework of the conceptual model. Finally, a coordinated procedure is developed which combines several of the most valuable characteristics in the individual methods.

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LIST OF ABBREVIATIONS

1. ABM - Anti-Ballistic Missile
2. ATLAS - Combat Simulation Model
3. C5A - Extremely Large Cargo Aircraft
4. DGMTO - Design Group of Multi-Theater Operations
5. DoD - Department of Defense
6. ECM - Electronic Countermeasures
7. FASTALS - Logistics Support Model
8. FCA - Force Cost Assessor
9. FDL - Fast Deployment Logistics Ship
10. FEBA - Forward Edge of Battle Area
11. FOREWON - Army Force Planning System
12. GAO - General Accounting Office
13. LSD - Lift (Transportation) System Designer
14. MIRAGE - Military Requirements Analysis Generator
15. OFD - Objective Force Designer
16. PATTERN - Planning Assistance Through Technical Evaluation of Relevance Numbers
17. PFD - Preliminary Force Designer
18. R&D - Research and Development
19. SST - Supersonic Transport
20. TCP - Technology Coordinating Paper
21. TFD - Theater Force Designer

ACKNOWLEDGEMENT

E.S. Quade, an experienced and respected analyst at the RAND Corporation, noted that in performing a systems analysis "a periodic reappraisal is essential because as the study progresses the analyst broadens his understanding of its scope and purpose. Stock-taking that results in junking a major portion of the work indicates that a reappraisal was especially necessary" [Ref. 23, p. 360]. The truth of his statement has become painfully evident in the course of developing the analytic procedure for this study. During a long and occasionally frustrating learning process, this author examined and discarded numerous different approaches to the problem before settling on the one presented here. He would therefore like to thank his wife, Michele, and his advisor, Dr. M.G. Sovereign, for their patience and cooperation during a process which must have appeared to involve a virtually endless series of changes and revisions.

I. INTRODUCTION

A. BACKGROUND

The process of acquiring major weapons systems for the Department of Defense (DoD) has been the subject of severe criticism in recent years. Reports of widespread "gold-plating" and "cost-overruns" in excess of $30 Billion have prompted investigations by the General Accounting Office (GAO) as well as several independent study groups [Ref. 1]. The findings of these investigations have indicated that one of the principal causes of difficulty is a failure to adequately identify needs before embarking on new programs. Former Deputy Secretary of Defense David Packard stated "The most certain way to waste resources is to spend hundreds of millions of dollars on a (weapon system) development and then conclude we will not need what we are developing" [Ref. 2, p. 2].

Since most major acquisition programs are initiated to provide replacements for existing systems, the specific requirements for them are often simply assumed to be valid without an investigation of their value in a projected force structure context. Mr. Packard suggested that this tendency to "think more in terms of what was effective in the last war rather than ... what might be needed for the future" is a primary cause of development difficulties, and he concluded that "no viable decision can be made on which weapons should

be developed without knowing in considerable detail what kind of forces will be needed for the future" [Ref. 2, pp. 2, 3]. The GAO concurred by further commenting that "Our study of the history of a fairly large sample of weapon systems leads us to conclude that the function of deciding which weapons will be developed is not yet being done with the degree of effectiveness that this important function warrants" [Ref. 3, p. 71].

B. PURPOSE AND APPROACH

This paper is the first half of a two part study designed to develop an effective procedure for estimating future military needs and compare it with actual DoD policies and practices in order to determine means for improving them. Since most of the applicable DoD policies are currently undergoing revision, the portion of the study which addresses them is being temporarily deferred until they are officially redefined. This segment, therefore, is concerned only with the development of a generalized procedural approach. Specifically, its purpose is to systematically identify and analyze the requisite components of an effective procedure for estimating future military needs as a basis for the planning of exploratory research and development (R&D) efforts.

In their findings on the Weapons Systems Acquisition Process, both the Blue Ribbon Defense Panel and the Commission on Government Procurement made several broad recommendations on how such a procedure should be developed. These

recommendations, as interpreted by the author, may be summarized as follows: Military needs should be estimated and evaluated within mission areas of the total Defense structure and should be expressed in terms of capabilities and concepts rather than systems and hardware [Refs. 4 and 5].

In the process of investigating the components of an effective estimation procedure, this study examines three separate facets of the problem: what elements and processes are involved; what methods are available for dealing with them; and how these methods can be most productively utilized. The investigation is conducted in the context of a conceptual model for estimating needs which is developed to illuminate a systematic procedural methodology through the use of a decision theory approach involving the processes of assessment, analysis, synthesis, and evaluation. The study commences in Chapter Two with a discussion of the inputs to the model. Next, the several processes involved are introduced and analyzed. Finally, a hypothetical method of operation for the model is presented.

The third chapter deals with the exploration of several different methods which have been developed to deal with the types of problems encountered in needs estimation. They are presented in terms of their actual application in this area.

The fourth chapter begins with a comparative evaluation of the previously introduced methods. It continues with the

development of a composite procedural approach which combines selected aspects of the individual methods.

The final chapter summarizes the results of the study and suggests several areas in which further analysis would be particularly beneficial.

II. CONSTRUCTION OF A CONCEPTUAL MODEL

A. INTRODUCTION

Since the estimation of future military needs is accomplished within the overall context of force planning, a survey of the general characteristics of this field provides insight into the factors and actions involved. Former Secretary of Defense Melvin Laird stated that "Acceptable force planning must be based not only on a definition of our objectives, but also on a sophisticated analysis of the nature and relative importance of the various implements and obstacles to the achievement of our objectives" [Ref. 6, p. 25]. While this statement does not reflect the tremendous difficulties involved in the force planning process, it does point out some of the factors which must be included. In this study, these factors (objectives, strategies, and capabilities of friendly and enemy forces) are treated as the inputs to a conceptual model which utilizes them to develop statements of future military needs.

In order to develop the characteristics for the conceptual model, it is necessary to begin with a description of its desired output. For the purposes of this study, this output (future military needs) may be defined as requirements for new and/or improved capabilities which will correct projected deficiencies in the military's ability to achieve its objective in the face of anticipated opposition. Since

the statements of these needs are designed for use by R&D planners, they should contain some rather specific information of the following description [Ref. 5]:

a) A statement of the deficiency to be corrected and the various concepts that appear to merit exploration in this regard.

b) The important objectives to be met by a responsive development effort, including general capability, availability, and cost goals.

c) The operational/environmental constraints that must be considered; such as size, simplicity, and intended usage.

B. THE INPUTS

While not an input per se, the environment has such a pervasive impact on the specified inputs that it is most appropriately discussed in this context. It may be defined as the total situational framework within which ALL elements and processes of the model are specified and implemented. Although the term scenario is normally associated with this definition, it is felt that environment is a more representative description of the comprehensive nature of the situational information required for meaningful specification of the inputs to the model. Examples of important parameters which must be included are the political, economic, and sociological conditions which are expected to exist during a period 10-15 years in the future. Since these parameters

comprise the frame of reference for the other aspects of the model, their determination is one of the most critical tasks in the development process.

The inputs themselves are separated into three basic types: objectives; strategies, and capabilities. Although there are different sets of these inputs for the two opposing forces in the model, the characteristics of a particular type of input are assumed to be independent of a "friendly" or "enemy" designation. The inputs are discussed in this chapter, therefore, without differentiation of the particular force involved.

Objectives, in this analysis, are defined as the military goals established to implement national security policy. They may vary greatly in both generality and importance and are highly sensitive to the environment. For instance, an aircraft carrier in the Caribbean might have a broad minor objective of conducting general surveillance during routine operations whereas, in a time of crisis, it might have the specific and major objective of deterring Cuban air attacks against its neighbors.

It is, therefore, necessary that the full range and hierarchy of objectives which apply in a particular situation be enumerated when specifying this input to the model. It is also important to examine their sensitivity to the environment so that appropriate modifications can be made when different environmental conditions are examined.

Another type of input to the model is capabilities. These are defined as the means used by the military to achieve its objectives. An example, might be the capability which an aircraft carrier possesses for projecting firepower against distant targets. Since capabilities are closely related to specific systems, such as combat aircraft in this example, they can be concretely specified in a particular situation more easily than objectives. It should be noted, however, that this statement does not imply a one-to-one correspondence between capabilities and systems. Some capabilities may require the simultaneous use of several different systems, while some systems may be able to provide multiple capabilities. It is, consequently, necessary to examine the relationships which exist between the relevant capabilities and systems when specifying this input to the model.

Strategies are the methods by which capabilities are utilized to pursue the achievement of objectives. As such, their primary purpose is to provide a coordinating interface between the other two types of inputs so that the intentions and actions of each force in a given situation can be determined and analyzed. Like objectives, strategies may vary widely both in generality and in sensitivity to the environment. For the aircraft carrier in the Carribean, a broad major strategy under normal conditions might be to monitor the sea and air traffic entering and leaving Cuba. During tense periods, however, a specific minor strategy might be

to avoid complications by keeping the area clear of friendly air traffic. Since strategies are highly dependent on both objectives and capabilities, as well as the environment, the effects of these other inputs must be carefully considered in their specification.

C. THE TRANSFORMATION PROCESSES

There are four different transformation processes in the conceptual model. The first involves a comparative assessment of the inputs in order to discover where significant deficiencies occur as a result of unfavorable imbalances between the friendly and enemy forces. The second process concerns an analysis of these deficiencies to isolate the particular capabilities that require improvement. The third deals with the synthesis of alternative concepts for providing such improvement. Finally, the last process involves iterative evaluations of these concepts under four important types of considerations.

The comparative assessment process is most easily discussed in terms of specific interactions between opposing forces. It entails a detailed analysis of the inputs in order to determine the respective intentions and tactics of the opposing forces. This data is then used to compare the relative strength and effectiveness of the forces in order to discover where friendly deficiencies occur.

The analysis of deficiencies in order to isolate the particular capabilities involved is a less complex task

than comparative assessment, but is often more difficult. It requires the translation of data in terms such as numbers of aircraft destroyed or amounts of territory lost into meaningful information concerning weaknesses in specific capabilities. Once this has been accomplished, the isolated weaknesses are further analyzed to determine whether they are most appropriately corrected by an increase in the quantity or an improvement in the quality of forces. Since this study is oriented toward R&D planning, only those deficiencies which indicate a need for developmental improvement are pursued.

The third process which occurs in the model concerns the synthesis of alternative concepts for correction of the capability weaknesses that have been isolated. These concepts are necessarily very general in nature and should include innovative as well as traditional methods for providing the type of capability involved. Also, their range should be as broad as possible in order to counteract the normal military tendency to focus on a single "preferred" approach.

The iterative evaluations occur as a result of four different types of environmentally related considerations which affect the validity of the concepts synthesized in the preceding process. Their purpose is to eliminate those concepts which are clearly invalid and to provide amplifying/qualifying data for those which are approved for inclusion in needs statements. Although they are discussed and illustrated in an apparently sequential fashion, they should be

performed simultaneously in order to examine the trade-offs involved.

The first type of evaluation deals with the operational usability of a concept. It is vitally important because the investment in a development based on an unusable concept is ultimately wasted. An example of such a situation involved the projected utilization of the C5A. An extensive development effort was undertaken to provide this aircraft with an expensive specially constructed landing gear system for use on both concrete and dirt runways. This effort was in response to a clearly unrealistic concept of utilizing this extremely large and vulnerable aircraft to transport troops into unimproved forward areas. In order to prevent such problems, it is necessary to evaluate proposed concepts in light of the operational conditions involved in their anticipated usage.

A second type of evaluation concerns the technical feasibility (including performance, cost, and schedule considerations) for a particular concept. The question here is whether an effective system based on the concept could be developed for an acceptable cost in the time frame desired. This evaluation entails a survey of projected technology in applicable fields as its primary source of information and involves extensive trade-offs between the three parameters concerned.

An example of the need for this kind of evaluation concerns the concept for the supersonic transport (SST)

which was developed by Boeing in the 1960's. As a result of many difficult engineering problems, numerous schedule delays, and skyrocketing costs, its development was finally terminated after the expenditure of vast amounts of time and money.

The third type of evaluation process involves the strategic considerations that may be involved in the enemy response to a particular development effort. A concept that is expected to evoke a strong or dangerous response may not be tenable in this context. The need for this type of evaluation is clearly illustrated in the controversy which surrounded the development of the anti-ballistic missile (ABM) in the middle 1960's. While many proponents of this tremendously complex and costly system argued that it was vital to the nation's defense, its critics felt that it was not a tenable concept. They argued that it would undoubtedly promote further armament escalations and would consequently be quickly neutralized by compensatory enemy developments.

The final type of evaluation in the model concerns the domestic political considerations associated with developments based on a particular concept. The question is whether a concept might involve implications that would be considered unacceptable by the electorate and/or Congress. An example of this type of situation can be found in the abandonment of the Navy's Fast Deployment Logistics Ship (FDL) concept. DoD presented this concept as a necessary and cost-effective improvement to the Sealift capability. It encountered

political opposition in two major areas, however, which ultimately forced its cancellation. First, commercial shippers united in opposition to the FDL because they feared it would curtail DoD's use of civilian cargo carriers. Also, several Senators feared that the concept would encourage undesirable U.S. involvement in "police-action" conflicts by making the movement of troops and supplies into overseas areas too fast and convenient for the exercise of adequate restraint.

Those concepts which are considered worthy of exploration after evaluation are combined with the deficiency they are to correct and appropriate amplifying/qualifying data into a statement of need as described in the introduction to this chapter.

D. A MODUS OPERANDI

The general flow of operations in the model and the characteristics associated with each section are depicted in Figures 1 and 2 respectively. In order to illustrate this methodology more clearly, the following simple hypothetical example is presented.

As part of an analysis undertaken to determine the quick response effectiveness of U.S. general purpose forces in the environment projected for the 1983-1988 time frame, a specific environmental situation is considered in which U.S. Marine amphibious forces are engaged in a police-action conflict with Arab forces in protection of a small but

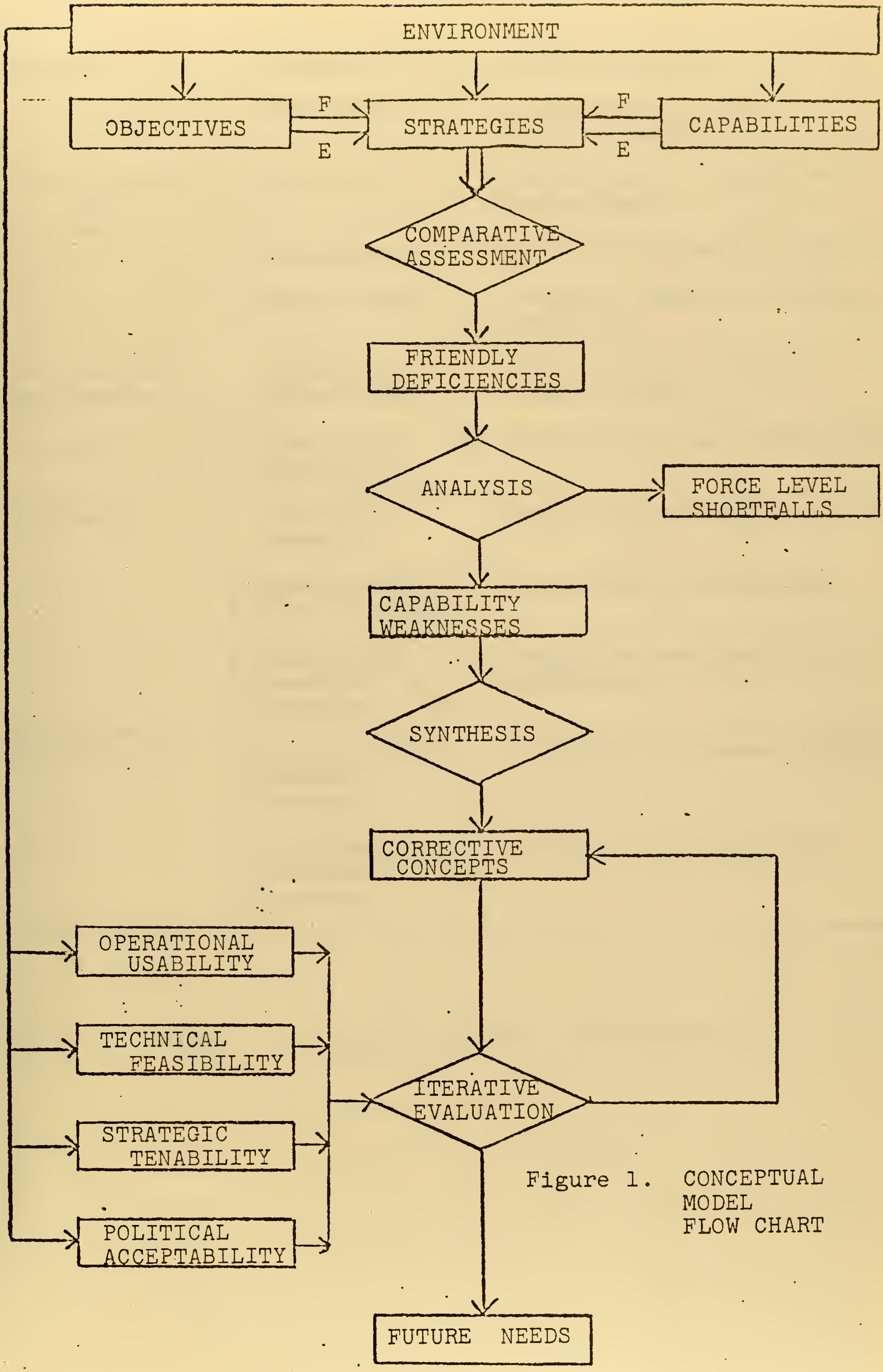

Figure 1. CONCEPTUAL MODEL FLOW CHART

Process	Product	Characteristics
Specification of Inputs	Environment	Comprehensive scope, highly uncertain
	Objectives	Hierarchical, sensitive to environment
	Strategies	Link objectives to capabilities
	Capabilities	Complex capability-system relations
Comparative Assessment	Friendly Deficiencies	Many elements, complex interactions
Analysis	Capability Weaknesses	Translation and categorization
Synthesis	Corrective Concepts	Broad and innovative in scope
Iterative Evaluations	Operationally Usable Concepts	Anticipated Utilization
	Technically Feasible Concepts	Projected availability of technology
	Strategically Tenable Concepts	Perception of enemy response
	Politically Acceptable Concepts	Congressional attitudes

Figure 2. CONCEPTUAL MODEL CHARACTERISTICS

oil-rich Middle Eastern nation. An in-depth analysis of this situation aids in the specification of the objectives, strategies and capabilities of both opponents. A comparative analysis of the forces involved indicates that the American force is suffering casualties at an unacceptable rate. Further investigation reveals that the apparent reason for the losses is an imbalance in the air support available to the two opponents. Specifically, the Arabs possess a Soviet-built close air support aircraft against which the American forces cannot adequately defend. An analysis of this deficiency reveals that it is not feasibly correctable through increases in force levels due to the non-existence of an adequate air defense capability or sufficient friendly air support in the environment involved. It is determined that the deficiency results in a 75% probability of survival from a single air attack and a 50% probability for successful conduct of sustained operations. An improvement in capability is desired which will increase these probabilities to 95% and 75% respectively. It is predicted that any one of a number of different concepts for providing the improved capability would be both operationally usable and technically feasible. Additional evaluations are performed to discover the effects of any strategic or political implications which may be involved. When they are determined to be negligible in all respects, the following statement of need is developed and promulgated to the R&D community.

a) A need exists for an advanced system to protect amphibious ground troops against air attack. While no currently projected systems are adequate, various concepts involving field operated missiles, laser weapons, or electronic countermeasures (ECM) devices appear to merit consideration.

b) The goal for a responsive system is provision of a 95% probability of survival from a single air attack and a 75% probability for the safe conduct of extended operations in a vulnerable environment. The single attack survivability criteria is considered more important than the criteria for extended operations. The capability should be available in the 1985 time frame and development efforts should be funded within the constraints set forth for normal exploratory/ advanced development projects.

c) Since the capability should be provided by a system that can be operated by front line troops in the field, such a system should be easily transportable, relatively maintenance-free, and operable by individuals with a minimum of formal training.

III. INVESTIGATION OF APPLICABLE METHODS

A. INTRODUCTION

The conceptual model developed in the previous chapter is rather difficult to "operationalize" due to a number of different problems. These problems arise primarily from three sources: The difficulties involved in adequately specifying the inputs; the tremendous complexity of the included processes; and the general uncertainty inherent in long-range estimation efforts. A number of different approaches to the tractable management of these problems have been developed.

The purpose of this chapter is to introduce several of these approaches as illustrations of alternative methodologies for the estimation of future military needs. As shown in Figure 3, there is considerable variance among these methods in usage and mathematical rigor as well as in procedural approach. Although the various approaches are not explicitly compared or evaluated in this chapter, it should be emphasized that the reason for introducing them is to demonstrate several tools which could be useful in the construction of a composite approach in the framework of the conceptual model.

Since the examples presented here are relatively condensed and abbreviated, readers who are especially interested in a particular approach are encouraged to consult the appropriate reference for a more thorough treatment.

TYPE OF METHOD	EXAMPLE UTILIZED	PRIMARY USAGE	TYPE OF INPUT DATA	TYPE OF DECISION CRITERIA	PROCEDURAL APPROACH
Threat/ Response	Weapons Technology Coordinating Paper	DoD R&D Coordination	Quantitative	Objective	Incremental Analyses
Delphi	Study in Deterrence	Pedagogical	Qualitative	Subjective	Expert Opinions
Relevance Tree	PATTERN	Industrial R&D Planning	Mixed	Mixed	Hierarchical Priorities
Functional Network	MIRAGE	Force/R&D Planning	Mixed	Mixed	Mission Flow Charts
Simulation	FOREWON	Army Force Planning	Quantitative	Objective	Computer Models

Figure 3. COMPARISON OF ALTERNATIVE METHODS

B. THREAT/RESPONSE

The traditional process of determining needs in DoD is based upon the assessment of a threat and the proposal of development concepts to counter it. Almost every requirements document published by the Department references some type of threat analysis as its justification [Ref. 7]. It is appropriate, therefore, that the first method discussed in this chapter should involve a variant of this procedure. The approach employed in developing a draft of the Technology Coordinating Paper for weapons development (a document being published by the Director, Defense Research and Engineering) was chosen for this purpose because it is substantially independent of environmental considerations.[1] Whereas most attempts at threat assessment are based on a detailed description of the environment in which the assessment is made [Ref. 8], this approach is more concerned with an objective evaluation of the characteristics of comparable weapons. These evaluations are made in the following four contexts.

a) In a face-to-face comparison of a <u>friendly weapon</u> versus an <u>enemy target</u>, threat is constituted by higher survivability of the target.

---

[1]The information concerning this approach is based on personal interviews with Dr. R.N. Stolfi of the Naval Postgraduate School who coordinated development of the threat analysis for the document involved.

b) In a face-to-face comparison of an enemy weapon against a friendly target, threat is constituted by extreme vulnerability of the target.

c) In a side-by-side comparison of the performance characteristics for similar friendly and enemy weapons, threat is constituted by superior performance of the enemy weapons.

d) In an evaluation of projected enemy weapons technology, threat is constituted by anticipated innovative advances or breakthroughs.

In the Weapons Technology Coordinating Paper, the threats (see Figure 4 for example) identified by this procedure provide the rationale for a survey of weapons-associated technology. The objective of this survey is a determination of the ability of the technological fields concerned to provide new/improved systems which show promise of effectively countering the identified threats.

While this procedure has obvious drawbacks, including its failure to consider the effects of quantity/quality tradeoffs, it does offer an interesting method for eliminating the "scenario dependancy" which is inherent in most threat assessments and requirements statements.

C. DELPHI

An interesting Delphi-type approach to needs estimation can be found in A Study of Deterrence which pursues the following objectives [Ref. 9, p. 1]:

PART A: Threat = Survivability of Target

Friendly Weapon	Enemy Target	Threat
M16	Foot Soldier	Low

PART B: Threat = Vulnerability of Target

Friendly Target	Enemy Weapon	Threat
Foot Soldier	AK47	High

PART C: Threat = Superior Enemy Performance

Friendly Weapon	Enemy Weapon	Threat
M16	AK47	Medium[1]

[1]Due to higher reliability of AK47

PART D: Threat = Faster Enemy Progress

Friendly Technology	Enemy Technology	Threat
Adequate	Superior	High[2]

[2]Due to enemy advances in laser research

Figure 4. THREAT ASSESSMENT EXAMPLE

a) "To forecast American defense needs in the decades of of the seventies, eighties, and nineties."

b) "To compare and analyze national security strategies with national objectives."

c) "To relate specific weapons systems or mixes to national strategies."

d) "To evaluate future weapons systems and national security strategies with national objectives."

The approach used in the study employs a combination of the Delphi technique and cross-impact analysis. In order to facilitate understanding of this methodology, a brief description of these two analytic tools follows.

The Delphi Technique is designed to produce a consensus opinion among a group of experts through an iterative process of individual interrogations and feedback [Ref. 10]. It was developed at the RAND Corporation in an effort to rectify some of the biasing effects inherent in group discussions. These effects principally concern the tendency for the dominant members of a group to monopolize the discussion and the pressure for unanimity exerted by holders of the majority opinion. Delphi alleviates these problems by physically separating the members of the group and by utilizing the devices of anonymity, controlled feedback, and statistical group response. These devices provide for several rounds of private interviews with each member of the group. During the interviews, the members are presented with summarized results of the previous round, including the median and

deviation of the responses, and are requested to reply with revised and/or refined opinions (supported by appropriate justification if significantly different from the median). This process is generally repeated for three or four iterations or until the deviation of the responses is considered sufficiently small.

Cross-Impact analysis is "a family of techniques that try to evaluate changes in the likelihood of occurrence among an entire set of possible future events and trends in light of limited changes in probability for some of the items in that set" [Ref. 9, p. 32]. It involves the construction of matrices in order to enumerate and evaluate the interrelationships which exist among different sets of elements (see Figure 5). The combination of this technique with Delphi provides a means for simultaneously identifying and evaluating both individual elements and the linkages between them. The Study in Deterrence uses three sequential applications of this combination to predict, in turn, the nation's objectives, capabilities, and strategies for the period 10-30 years in the future.

Delphi One is concerned with determining and scaling "the specific goals and objectives of the United States in the area of National Security Affairs" [Ref. 9, p. 3]. It approaches this task by dividing National Security Goals into the categories of Deterrence, Defense, Maintenance Acquisition, and Development (with appropriate specific goals in each category as shown in Figure 6). The respondents are requested

Procedure: In order to investigate the relationships between four strategies (A,B,C,D) and three objectives (X,Y,Z), a cross-impact matrix could be constructed and evaluated as follows:

The effect on achievement of this objective would be:

If this strategy were pursued:		X	Y	Z
	A	+2	-1	-2
	B	+4	0	+1
	C	-4	+2	+3
	D	-1	+3	-2

where:

+1 to +5 denotes increasingly positive effect

0 denotes no effect

-1 to -5 denotes increasingly negative effect

Figure 5. ILLUSTRATION OF A CROSS-IMPACT MATRIX

AMERICAN NATIONAL SECURITY GOALS	Value	Priority
Deterrence of Strategic Nuclear Warfare		
Deterrence of Limited Nuclear Warfare		
Deterrence of Theater Conventional Warfare		
Deterrence of Sub-Theater or Localized Warfare		
Defense of American Population Centers		
Defense of National Command Authority		
Defense of American Economic System		
Defense of American Military and Military Support System		
Defense of American Retaliatory Forces		
Defense of American Territory		
Maintenance of American Collective Security System		
Maintenance of NATO Alliance in its Present Form		
Maintenance of SEATO Alliance in its Present Form		
Maintenance of the OAS		
Maintenance of Present Middle East Balance of Power		
Maintenance of East Asian Balance of Power		
Maintenance of Status Quo in South Asia		
Maintenance of Strategic Sufficiency		
Maintenance of Technological Superiority		
Acquisition of Further Strategic Arms Limitation		
Acquisition of Limitation of Nuclear Weapons Proliferation		
Acquisition of Favorable Balance of Trade		
Acquisition of Necessary Raw Materials and World Markets		
Development of a New Atlantic Alliance		
Development of a New Economic Relationship with Japan		
Development of a New Economic Relationship with PRC		
Development of a New Economic Relationship with USSR		
Development of Economic, Social, Political Stability in Latin America		
Development of Economic, Social, Political Stability in Africa		
Development of Economic, Social, Political Stability in South Asia		
Development of Economic, Social, Political Stability in East Asia		
Development of European Integration		

Figure 6. DELPHI ONE

to indicate the individual worth of each goal (on a scale of -1 to +3) and its relative priority within the entire set (on a scale of 1 to 9).

Delphi Two has as its objective the determination of the strategies which can best assure achievement of the objectives established in Delphi One. It endeavors to discover "the possible range of strategic options, and then to scale these options in terms of preference, utility, and probability of effectiveness" [Ref. 9, p. 3]. The procedure utilized delineates a number of possible strategies and policy attributes (Figure 7) and calls for respondents to evaluate them in three different contexts. First, the policy attributes are ranked in order of importance (Figure 8). Second, in a cross-impact context, the strategies are evaluated against the objectives established in Delphi One in terms of whether each of the strategies (in turn) is beneficial, neutral, or detrimental to the achievement of each of the objectives (Figure 9). Finally, in a similar manner, the strategies are evaluated against the various policy attributes in terms of the natures (positive, negative, or zero) of the correlations which exist between them (Figure 10).

The objective of Delphi Three is "to determine, in kind and quantity, the general weapons system types necessary to carry out the optimum National Security Strategies of the United States" [Ref 9, p. 4]. The weapons systems are divided into categories according to their usage, such as "balance" forces, defensive forces, or projection forces.

Strategies

Unrestricted Nuclear	Selective Targeting
Countervalue Nuclear	Counterforce Nuclear
Offensive Nuclear	Defensive Nuclear

Pre-Emptive Nuclear

Offensive Conventional	Defensive Conventional
National Liberation	Military Aid

Fortress America

Policy Attributes

Deters Attack:

Nuclear — Conventional — Insurgency

Feasible:

Politically — Economically

Flexible — Safe — Stable

Figure 7. DELPHI TWO STRATEGIES AND POLICY ATTRIBUTES

RANKING OF POLICY ATTRIBUTES

This is an attempt to determine preferences as to the ordering of importance of policy attributes using a special statistical technique. Notice that the matrix below has identical rows and columns, but that only half the matrix is provided. Starting with the attribute in row #1, compare this attribute to the attribute in every column for which there is a square to fill. If the row attribute is preferred to the column attribute, place a "1" in the square; if vice-versa, place a "0" in the square. Repeat this procedure for each row until the half-matrix is entirely filled with "1"s and "0"s.

				B	C	D
EXAMPLE:	Row A:	prefer	A to B A to C D to A	1	1	0
	Row B:	prefer	C to B B to D	B	0	1
	Row C:	prefer	C to D		C	1

Figure 8. DELPHI TWO, PART A

STRATEGY VERSUS GOAL

In the matrix below, strategies are listed as rows and goals are listed as columns. Starting with the strategy in row #1, evaluate the strategy against the goal in each column according to the following scoring system:

1 - the strategy is severely detrimental to the accomplishment of the goal.

2 - the strategy hinders the accomplishment of the goal.

3 - the strategy neither hinders nor contributes to the accomplishment of the goal.

4 - the strategy contributes to the accomplishment of the goal.

5 - the strategy is very beneficial to the accomplishment of the goal.

Repeat this procedure for each row. Remember, each strategy is to be considered independently of all other strategies.

	G1	G2	G3	G4	G5
S1					
S2					
S3					
S4					
S5					

Figure 9. DELPHI TWO, PART B

STRATEGY VERSUS POLICY ATTRIBUTE

This section is identical in method to part B, except the following scoring system is used:

1 - the strategy possesses the opposite of the listed attribute.

2 - the strategy has neither the attribute nor the opposite.

3 - the strategy possesses the attribute.

	A	B	C	D	E
S1					
S2					
S3					
S4					
S5					

Figure 10. DELPHI TWO, PART C

The respondents are requested to predict the technological feasibility of various concepts for advanced weapons (Figure 11). They are also asked to evaluate the cross impact of these concepts in terms of their usefulness in implementing the Delphi Two strategies (Figure 12).

Although this Study is not yet completed and is therefore very difficult to objectively evaluate at the present time, it does appear to offer an interesting approach to the difficult problem of predicting such subjective and judgemental elements of national security policy as objectives and strategies.

D. RELEVANCE TREE

Planning Assistance Through Evaluation of Relevance Numbers (PATTERN) is a procedure designed by Honeywell to "help pinpoint which of thousands of possible alternative research and development projects are most likely to provide maximum payoff in advancing important national-military objectives" [Ref. 12, p. 56]. Its methodology employs a type of hierarchal network known as a relevance tree to explicitly determine and display the relative importance of different specifically defined elements to the achievement of broadly defined goals.

The PATTERN procedure is initiated with a detailed projectivion of the environment for the time frame under consideration. Within this context, a relevance tree is developed which consists of a three section hierarchy [Ref. 13].

	WEAPONS	Degree of Feasibility	Reason(s) for Infeasibility
	Degree of Feasibility 0 - Clearly infeasible 1 - Possibly infeasible 2 - Clearly feasible		
BALANCE FORCES	1. Biological weapons (Lethal)		
	2. Biological weapons (Temporarily debilitating)		
	3. Chemical weapons (Lethal)		
	4. Chemical weapons (Temporarily debilitating)		
	5. Submarine-launched nuclear weapons		
	6. Land-based missile delivered nuclear weapons		
	7. Fixed-platform, underwater-launched nuclear weapons		
	8. Manned bomber delivered nuclear weapons		
	9. Doomsday machine		
	10. Army forces stationed abroad (Hostage forces)		
DEFENSIVE FORCES	1. Anti-ballistic missile forces (ABM)		
	2. Continental air defense systems less ABM		
	3. Civil defense systems (Shelters, underground industry		
	4. Continental land defense forces		
	5. Sea Control forces (Carriers, surface, cruise-missile ships) (Anti-submarine warfare forces)		
PROJECTION FORCES	1. Mobile land defense forces (STRAF and Marines		
	2. Naval tactical air forces		
	3. Land-based tactical air forces		
	4. Sea control forces (Carriers, surface, cruise-missile ships)		

Figure 11. DELPHI THREE, PART A

In this Delphi iteration, rate the capability of various types of weapons systems to implement the previously delineated strategies. It is assumed at this point that all of the types of weapons systems listed below are in fact feasible.

In the following matrix, rank the capability of each type of weapon system to implement each strategy. A ranking of 0 to 4 as defined below should be used:

0 - No capability. The weapons system is of no use in implementing the strategy.

1 - Slight capability. The weapons system may be capable of partially implementing the strategy under some circumstances.

2 - Moderate capability. The weapons system is capable of implementing the strategy under most circumstances in conjunction with other weapons systems.

3 - Large capability. The weapons system has significant capability to implement the strategy, but could be replaced by another system or combination of systems.

4 - Essential. The strategy cannot be implemented without this type of weapons system.

WEAPON VERSUS STRATEGY

	S1	S2	S3	S4	S5
W1					
W2					
W3					
W4					
W5					

Figure 12. DELPHI THREE, PART B

The upper section is concerned with overall strategies for achieving national objectives. It is divided into three separate levels which respectively delinate the types of conflict, forms of conflict, and missions which are involved in the development of these strategies. The center section deals with the capabilities that are required to implement the chosen strategies. Its two levels consist of the concepts and the functional subsystems involved in providing these capabilities. The lower section concerns the technological considerations involved in the development of the required capabilities. Its levels include subsystem configuration and technology deficiencies. Each of the levels, in turn, is broken down into elements which delineate the alternatives which are applicable at each level of the tree.

When a tree has been constructed and broken down into elements for each level, a team of experts assigns relative numerical values to these elements on the basis of predetermined weighted criteria [Ref. 14]. These values are assigned in the following manner. First, the criteria involved in a particular section of the hierarchy are given relative weights (in accordance with their importance) which sum to unity for all criteria in that section. Then, the elements on a particular node of the tree are assigned relative values under each of criteria applicable to it. These values are assigned in such a way that the sum of all the element-criteria valuations on a given node sum to unity.

By a series of element value multiplications along a linear trace "up" the tree, it is ostensibly possible to determine the relative importance of upgrading a particular element in terms of its individual effect on national objectives.

The following series of figures illustrates the PATTERN structure just described. Figure 13 shows the basic structure of the tree with suggested general ranking criteria for each section on the left and a hierarchy of the levels within the sections on the right. Figure 14 provides an example of a network structure which displays the elements that might comprise the top four levels of the tree. Figure 15 illustrates the numerical relationships among various levels in the context of an annotated relevance tree, showing the values placed on the elements of each node.

The numerical values provided in this manner comprise the major portion of the PATTERN data base. There are, however, two other sources of data which contribute to the final determination of relevance numbers for the elements in the tree. These sources are analyses of status/timing and cross support. Status/timing concerns the feasibility of correcting specific technical deficiencies listed on the lowest level of the relevance tree. A technological forecast, which predicts the future state-of-the art in the field(s) of technology concerned, is used as a basis for assigning relative values to the deficiencies as a measure

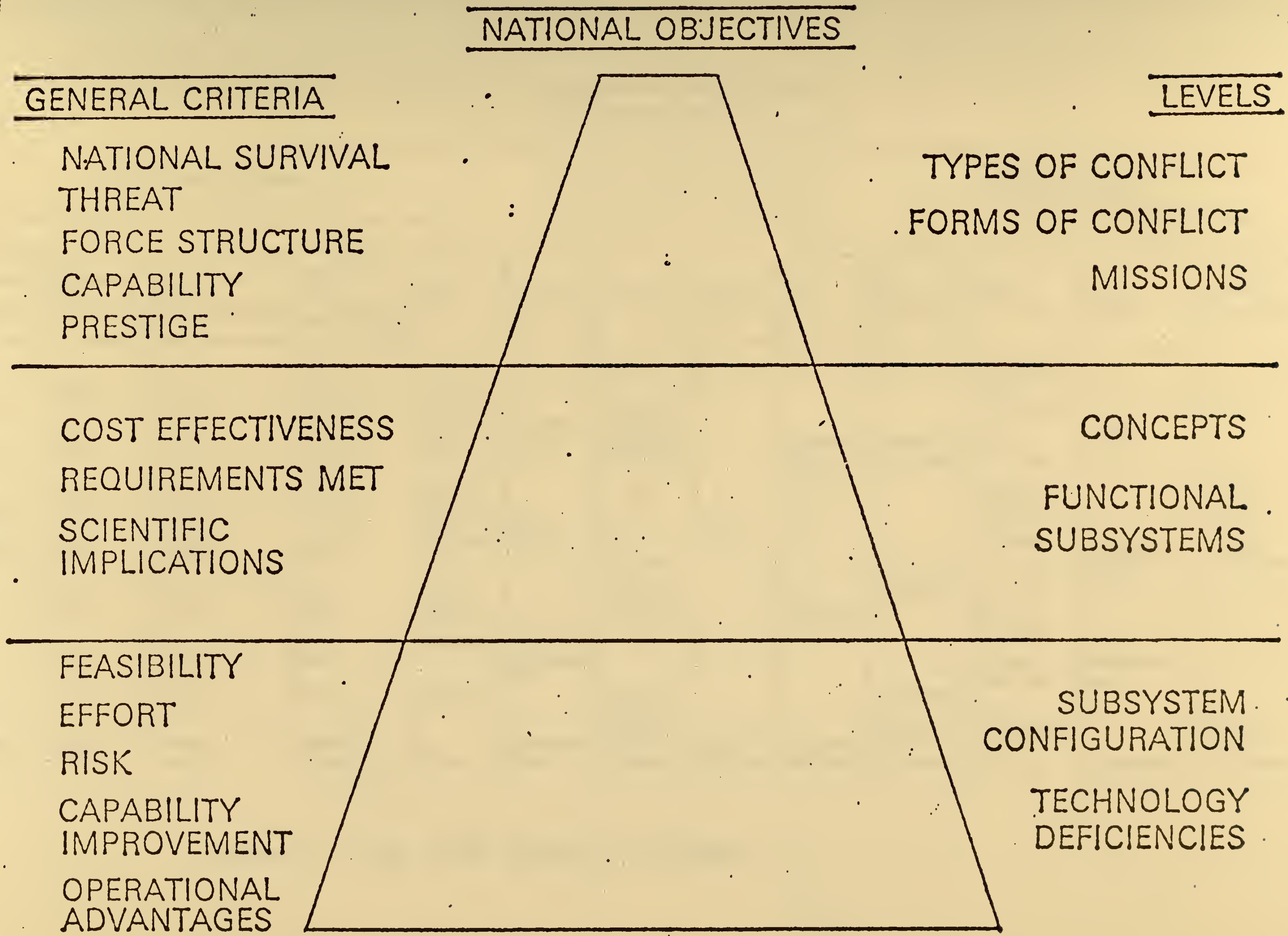

Figure 13, OVERALL PATTERN HIERARCHY

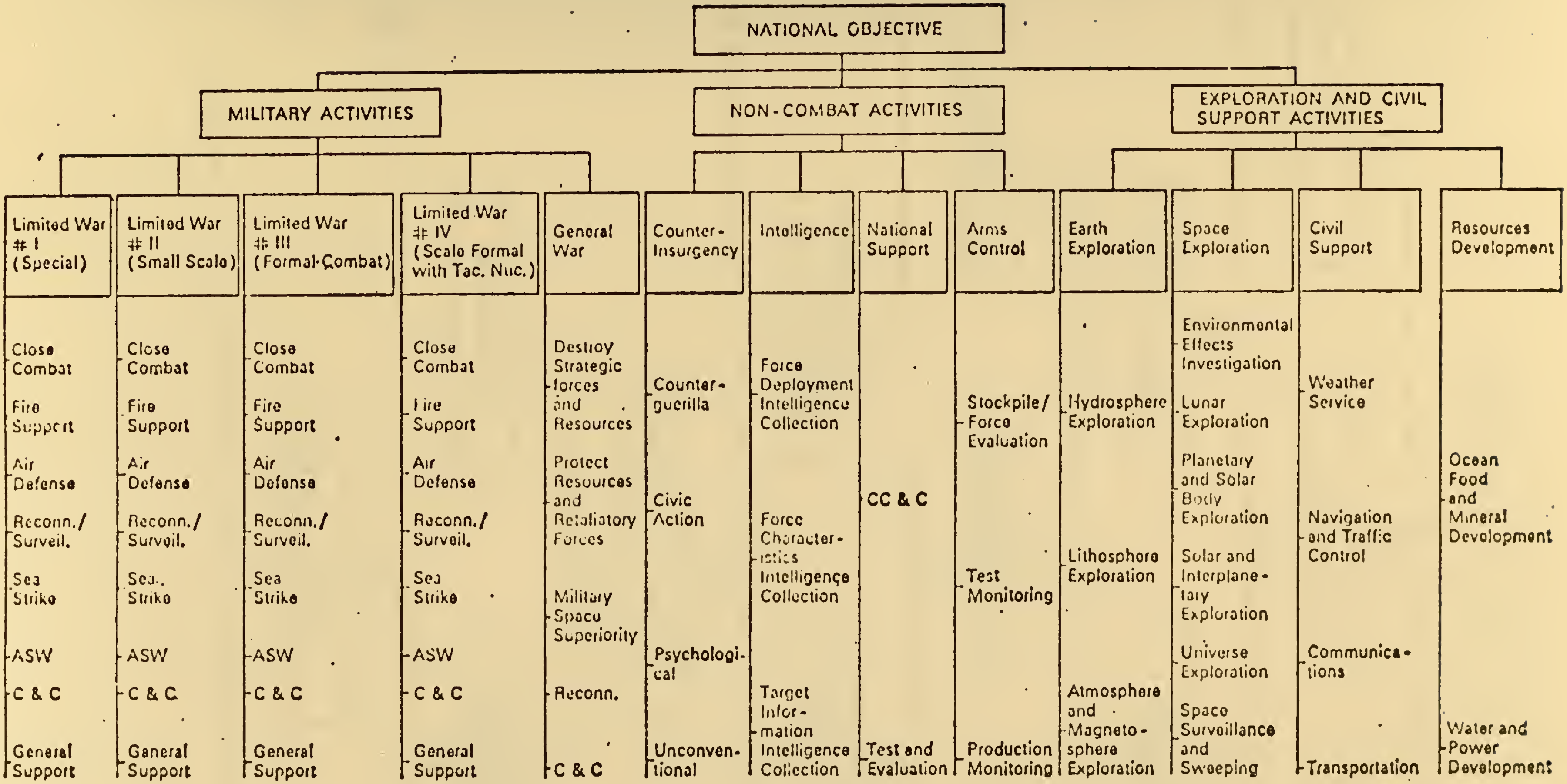

Figure 14. TOP FOUR LEVELS OF PATTERN

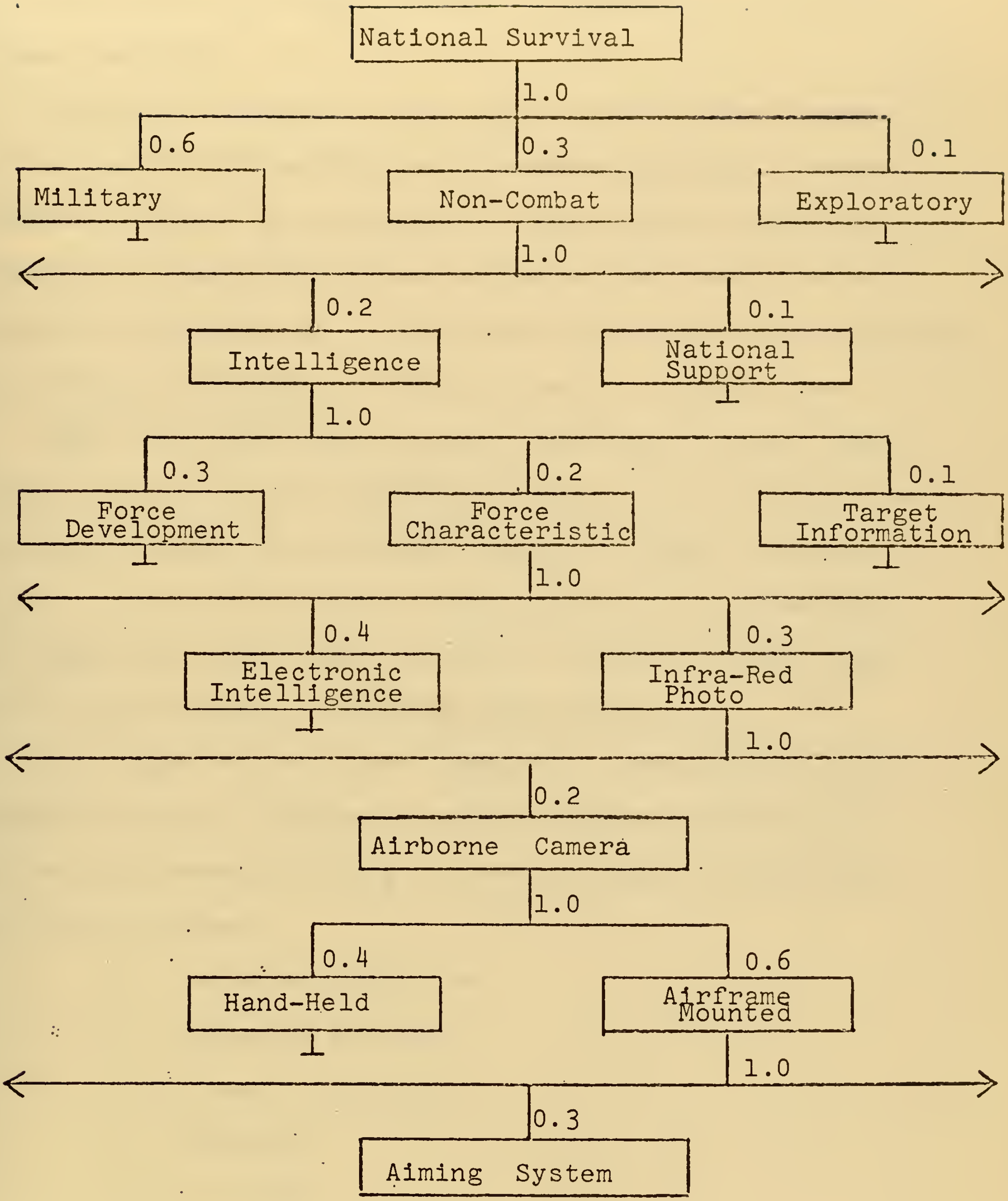

Figure 15. AN ANNOTATED PARTIAL RELEVANCE TREE

of the probability that they can be corrected in the time frame specified.

The third component of the data results from a survey of the relationships that exist between different technological fields. On the basis of this survey, values are assigned to the deficiencies to denote the general extent that the correction of a particular deficiency will encourage or aid the correction of deficiencies in related areas.

When all of the data has been developed for the three steps involved in the PATTERN procedure, it is compiled and analyzed through an automated process in order to produce a set of relevance numbers which indicates the priorities for upgrading individual elements in terms of their value to the achievement of national objectives.

As an indication of the complexity involved in a full PATTERN analysis, Honeywell developed and evaluated the following hierarchy during a six-month study effort based on this procedure.

.1 national objective

.3 types of activity

.13 forms of activity

.46 missions

.160 concepts

.425 functional sub-systems

.850 sub-system configurations

.200 technical deficiencies

While this approach contains a number of specific virtues and pitfalls, its primary value in determining needs appears to be the methodology it employs for displaying the general hierarchical structure rather than prioritizing the individual elements. Also, only the top five levels of the tree are applicable to the needs estimation problem as defined in this study.

E. FUNCTIONAL NETWORK

The functional network approach utilized in the Military Requirements Analysis Generation (MIRAGE) studies performed by Lockheed attacks the deficiency determination and evaluation problem from a mission oriented point of view. This procedure involves the development of extensive networks which outline the relationships that exist between missions, capabilities, and systems. These networks form the framework within which operational needs are isolated and corrective concepts are proposed. Their development grew out of a study performed at the RAND Corporation which attempted to illuminate the difficulties associated with planning for general purpose force structure requirements [Ref. 15].

The functional network analysis procedure (Figure 16) begins with the development of a set of environment scenarios which delineate a full range of conflict situations which are deemed possible for the time frame under consideration (see Figure 17). This information forms the basis for a development of the concepts of operation (strategies) which

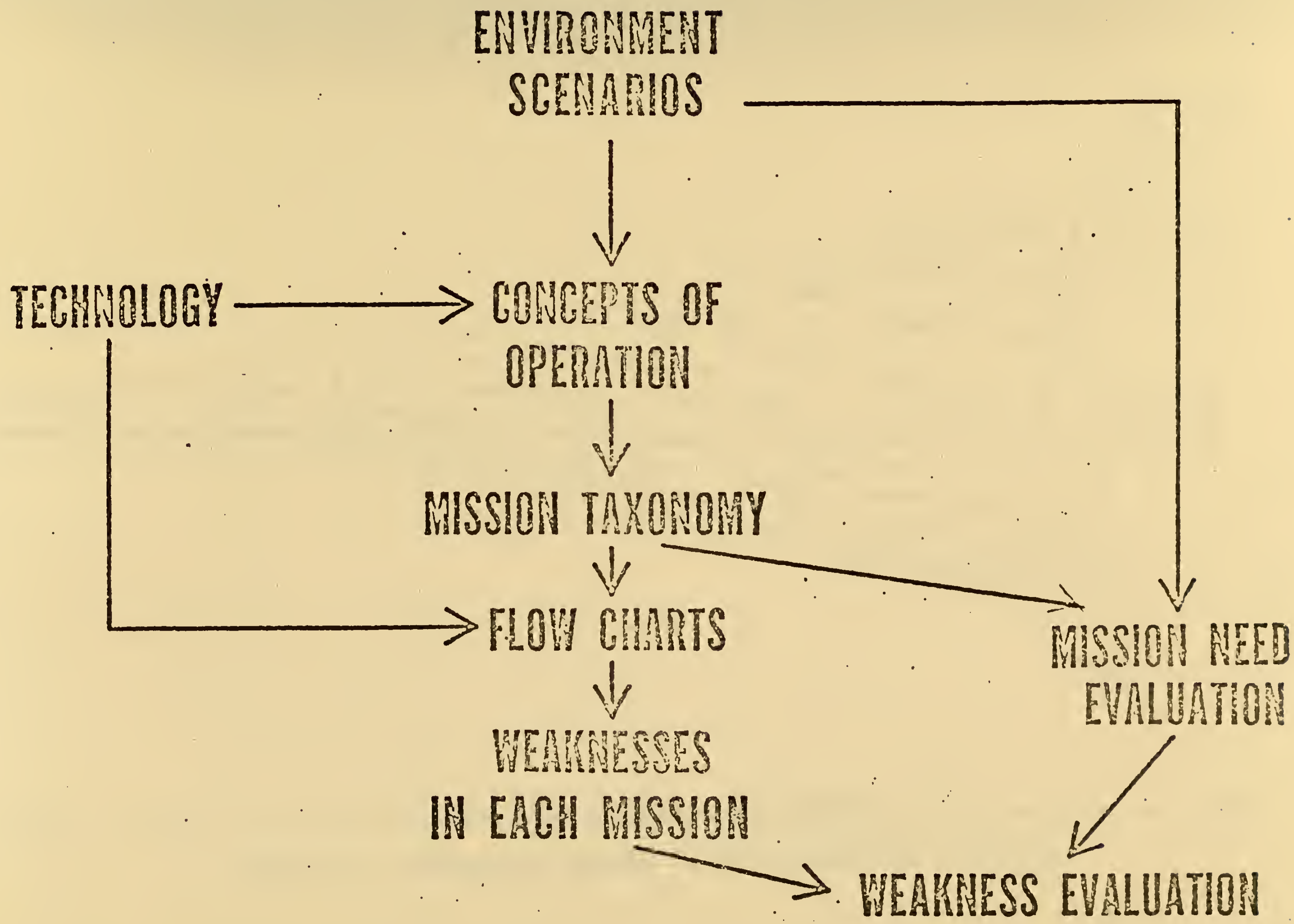

Figure 16. MIRAGE PROCEDURAL FLOW CHART

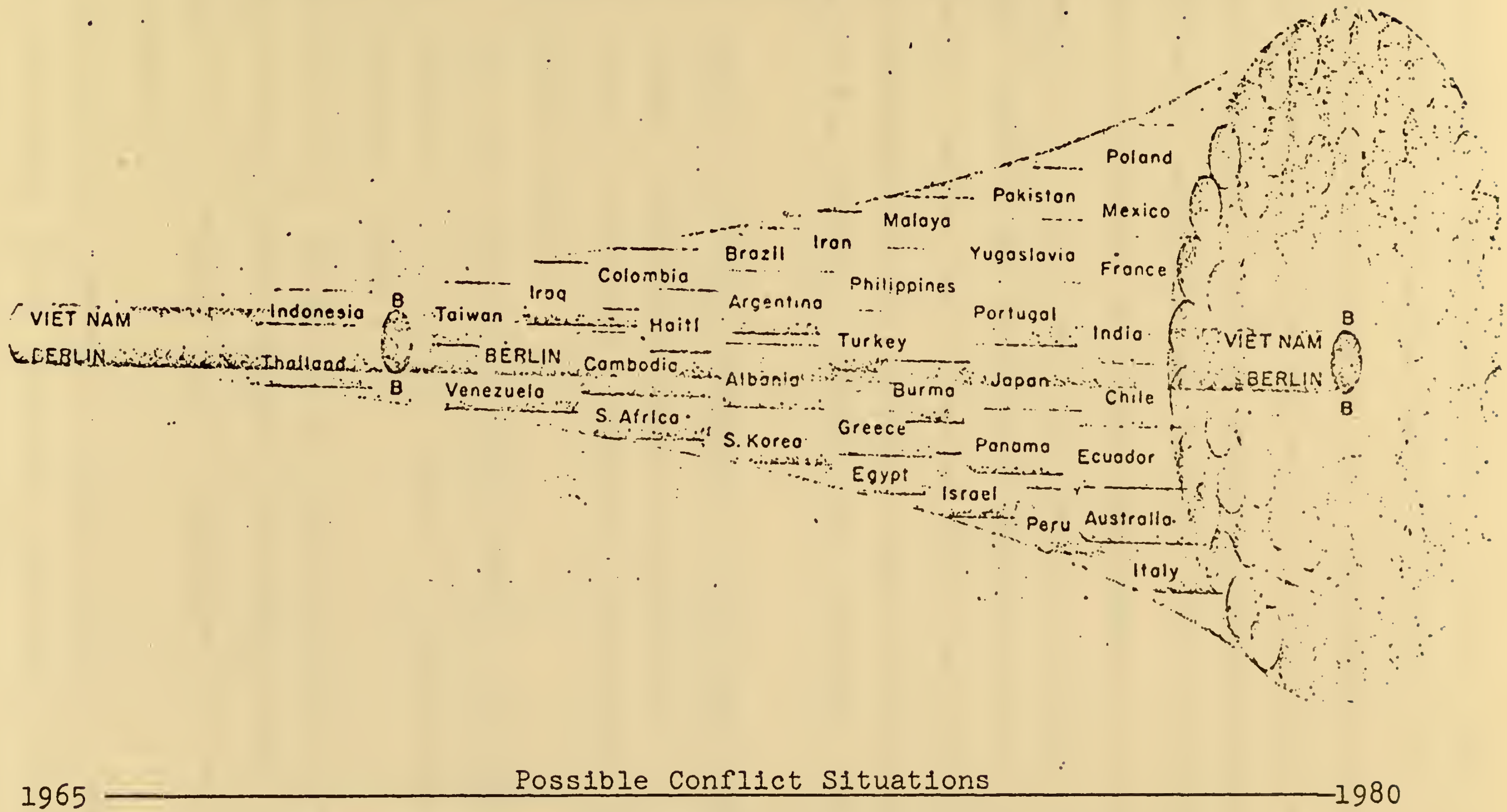

Figure 17. EXPANDING NATURE OF ENVIRONMENTAL ANALYSIS

are likely to be employed [Ref. 16]. The next step is a delineation of the missions which will be required in support of these concepts (Figures 18, 19). Each mission leads to the development of a detailed series of flow charts which outline the various types of capabilities required and weapons available for performing the different missions involved. Figures 20-22 provide an illustrative example of this process. By showing both capability requirements and systems availability together, the flow charts readily point out deficiencies which comprise the weaknesses within each mission area. These weaknesses are then ranked in terms of their importance by use of the following (PATTERN-like) procedure [Ref. 17, p. 81]:

a) "relate the missions by means of relevance numbers."

b) "assign 'likelihood' values to scenarios."

c) "combine the values of a) and b) to ascertain relative mission needs."

d) "rank the weaknesses isolated within each mission area."

e) "combine the values of c) and d) to asecertain relative functional needs."

After the various weaknesses are identified and prioritized, detailed technological forecasts are consulted and advanced concepts for correcting them are synthesized and evaluated for feasibility.

This procedure possesses a highly desirable characteristic not evident in the approaches discussed previously in that it attempts to explicitly delineate the tremendously

Mission		Present Prime Responsibility			
A.		Army	Navy—USMC	AirForce	Other
5	Coastal Patrol—Blockade		N		
6	Underwater Detection and Kill		N		
7	Strengthening Will to Resist				DOD—State
8	Air Defense	A	N	AF	
9	Denial of Facilities Useful to an Enemy	A	N	AF	
11	Show of Force	A	N	AF	
15	Destruction of Close Ground Targets by Ground Action: Anti—personnel	A	M		
16	Destruction of Close Ground Targets by Ground Action: Anti—armor	A	M		
18	Destruction of Distant Ground Targets	A	N	AF	
19	Destruction of Close Ground Targets by Air	A	N	AF	
21	Reconnaissance—Long Range	A	N	AF	
22	Reconnaissance—Ground Combat Area	A	N—M	AF	
23	Mobile Platform (for aircraft operations)	A	N—M	AF	
24	Amphibious Landing		N—M		
25	Aid Post—War Recovery				State?

Figure 18. MIRAGE COMBAT MISSIONS

Mission	Present Prime Responsibility			
B.	Army	Navy—USMC	AirForce	Other
Anti—Communist Type				
(2) Control of Land Area (also U.N. type)	A	N		CIA?
(3) Border Observation (also U.N. type)	A	N	AF	
(4) Creation of Land Barrier (also U.N. type)	A	N	AF	
(14) Weakening Existing Political and Military Control	A			State? CIA?
U.N. Type				
(10) Separation of Hostile Military Units	A	N	AF	
(13) Neutralization of Ground Forces Without Destruction	A	N	AF	?
(20) Raids (also population explosion type)	A	N	AF	?
C. Possible Future Missions				
Population Explosion Type				
(1) Defense of Natural Resources		N	AF	
(12) Destruction of Natural Resources	A	N	AF	
Other				
(17) Punitive Action	A	N	AF	

Figure 19. MIRAGE COLD WAR MISSIONS

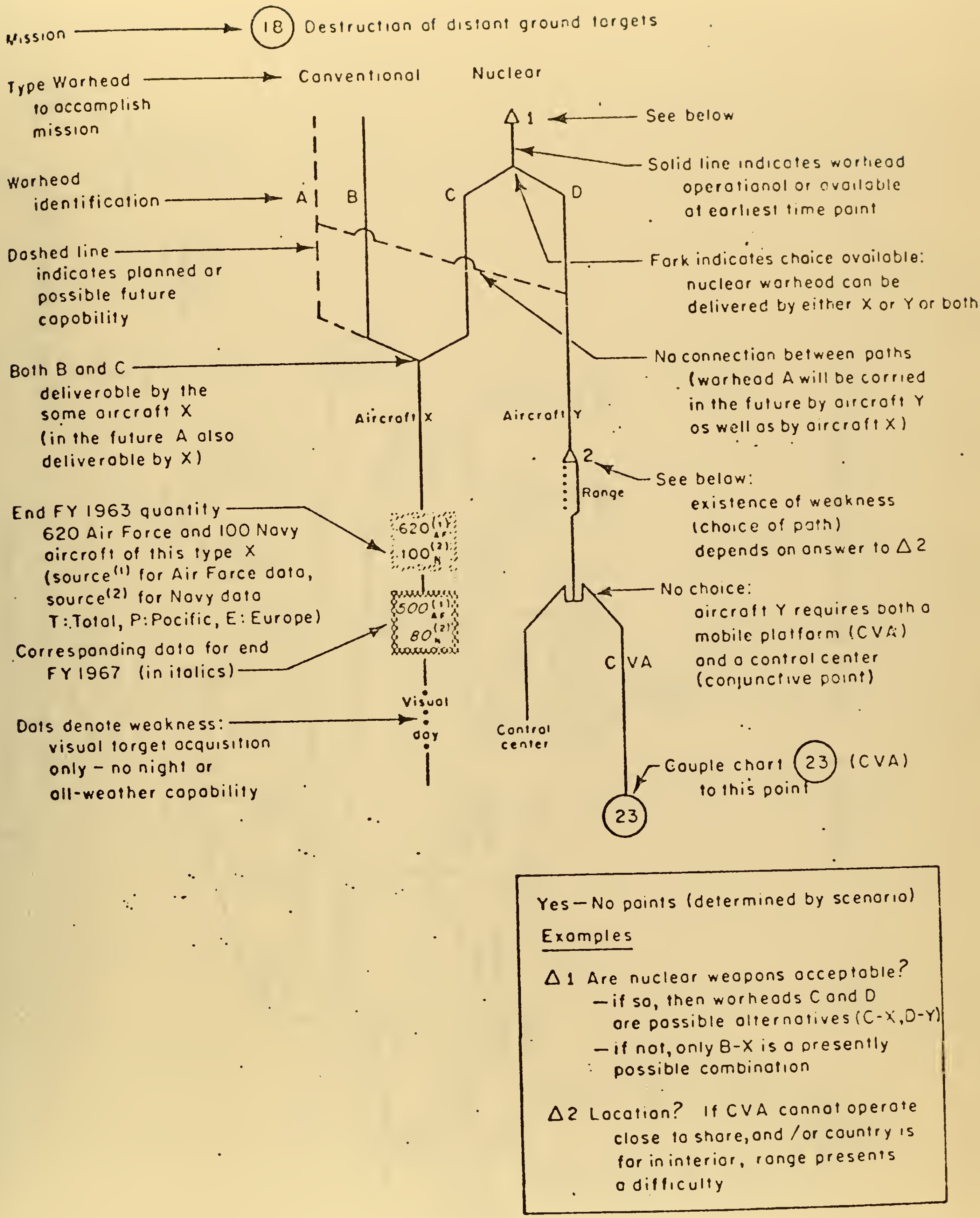

Figure 20. MISSION FLOW CHART KEY

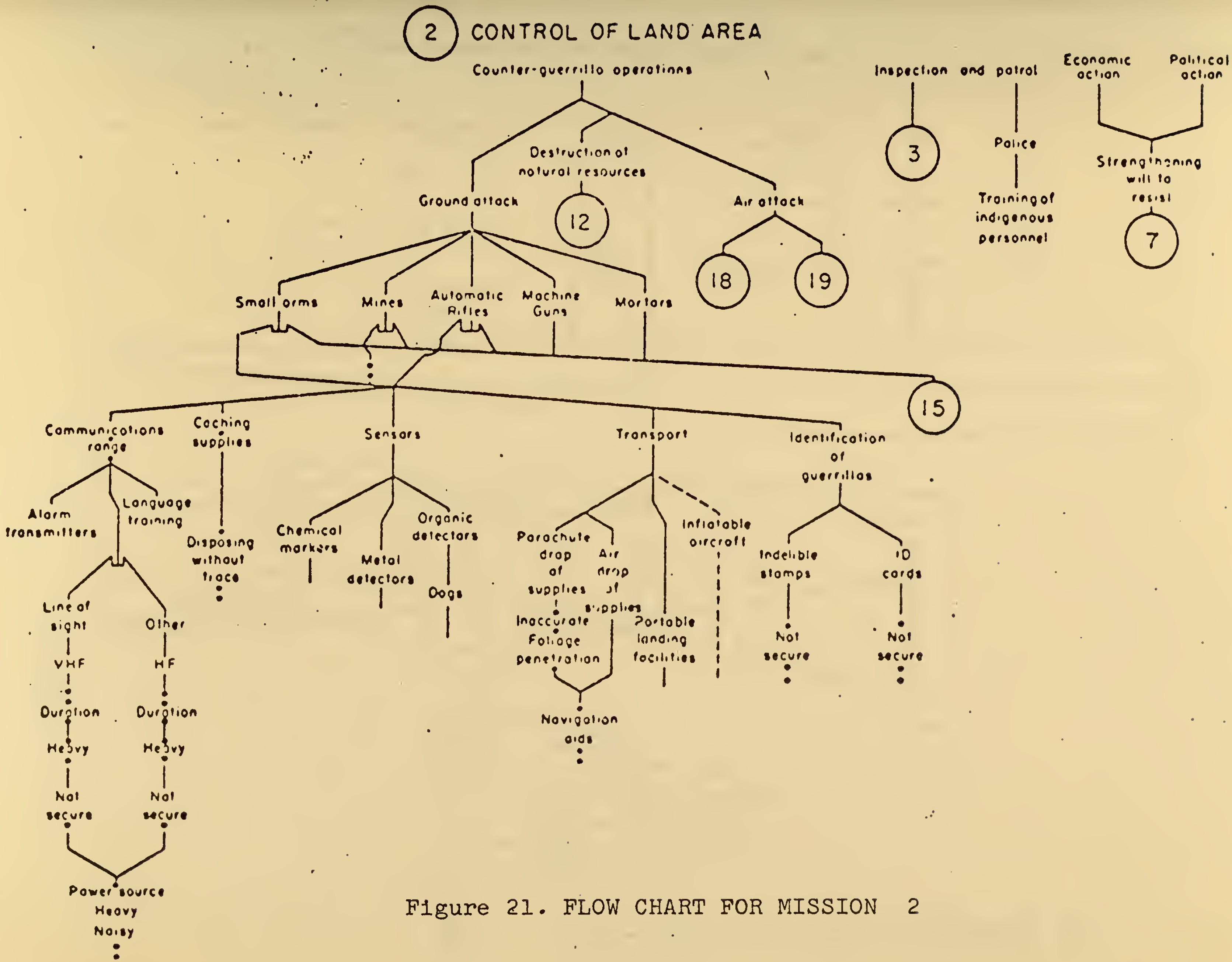

Figure 21. FLOW CHART FOR MISSION 2

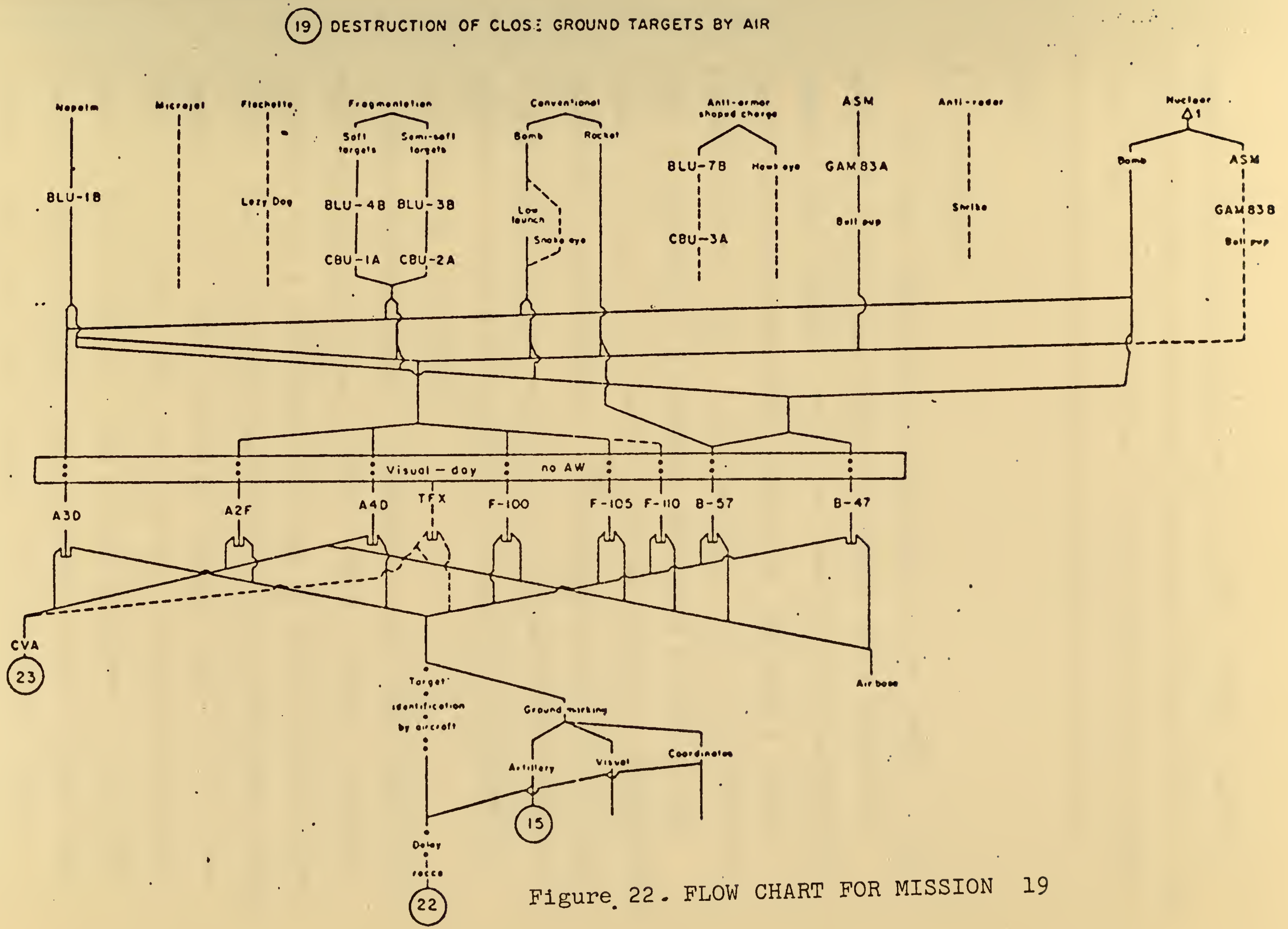

Figure 22. FLOW CHART FOR MISSION 19

complex inter-relationships which exists between capabilities and systems in the area of general purpose forces. For this reason it shows promise of being particularly valuable in any effort to realistically estimate future military needs.

F. SIMULATION

The final approach to be analyzed in the chapter is an extremely complex and highly automated force simulation system called FOREWON, which was developed by the Research Analysis Corporation (RAC) for use in the Army's program planning process [Ref. 18]. Although this system differs from the approaches previously discussed in that it is oriented toward optimization of force structure rather than isolation of deficiencies, it provides insight into a type of simulation system currently in DoD usage which might be adapted to the needs estimation procedure (see Figure 23 for a system flow chart).

The principal input to FOREWON is the Design Group of Multi-Theater Operations (DGMTO) which contains a set of scenarios for a particular strategy of multi-theater operations. The first operative module is the Preliminary Force Designer (PFD) which develops a combat troop list for execution of a DGMTO. This list is fed to the more detailed Theater Force Designer (TFD), which consists of the ATLAS combat simulation model, which conducts and evaluates the battle, and the FASTALS theater roundout model, which

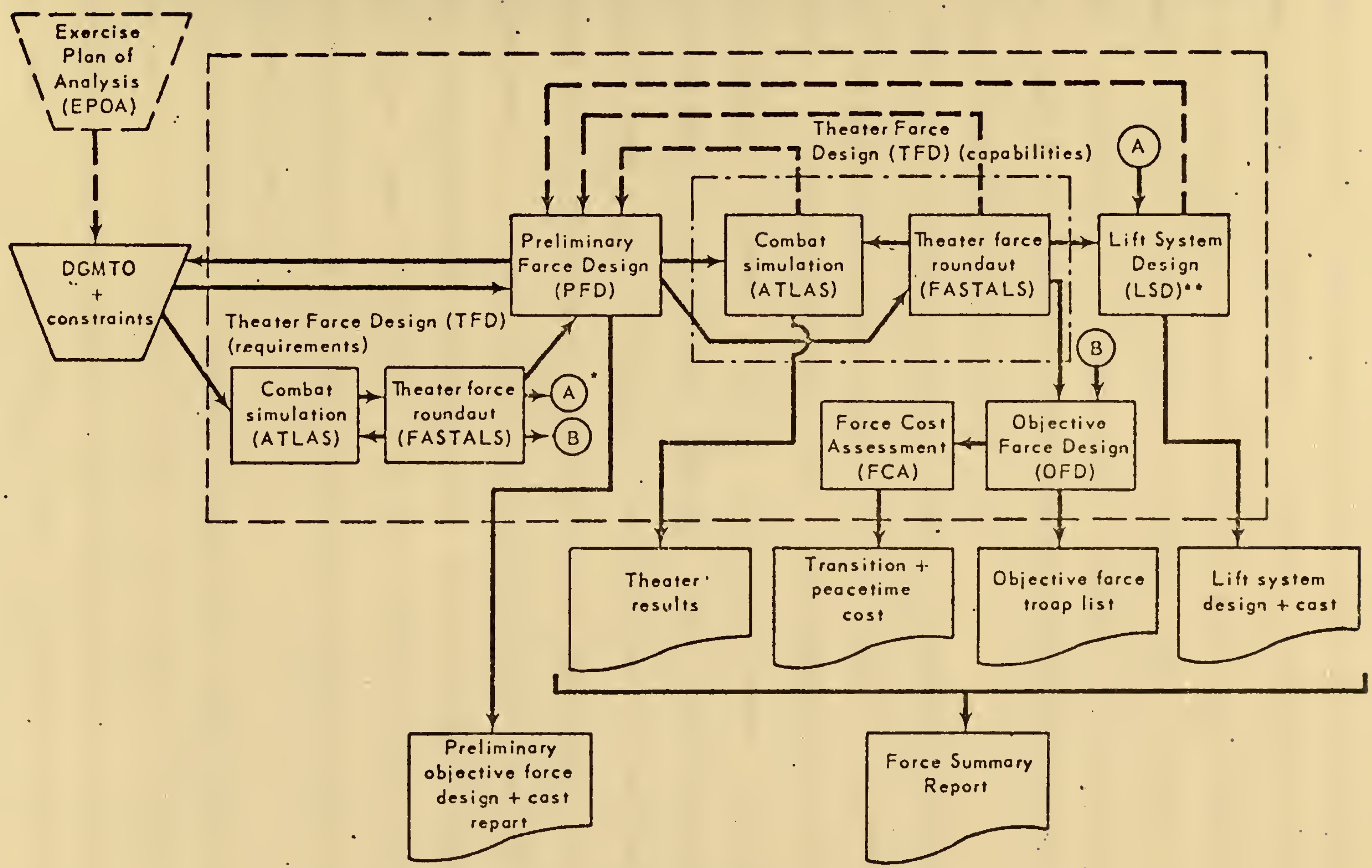

Figure 23. FORWON FLOW CHART

generates support requirements. While the ATLAS results are printed out directly, the FASTALS lists are fed into the Lift System Designer (LSD) and the Objective Force Designer (OFD). These modules, respectively, generate the design and cost for an appropriate transportation system and compile an overall optimal troop list. Finally, this optimal troop list is fed into the Force Cost Assessor (FCA) which computes and reports the cost of transitioning from an initial force to the objective force [Ref. 19].

While the system employs highly iterative procedures, as illustrated in the chart, a simplified "straight-through" version of the operational flow is illustrated by the following example. First, a DGMTO covering several contingencies is developed and fed into the PFD. The resulting initial combat troop list is inputted to ATLAS which evaluates its combat effectiveness and FASTALS which generates its support requirements. These lists are then used by the LSD to compute transportation requirements and the OFD to develop the objective force. Finally, the FCA computes the incremental costs associated with the transition from the initial to the objective force.

Although this discussion provides a very brief description of the system's operation, it is only intended to illustrate the general character and complexity of the processes involved. Since the ATLAS combat simulation model is of particular importance to the system's applicability in this study, however, its operation merits closer scrutiny (Figure 24).

PREGAME PREPARATION

analysis of situation
inputs aggregated

DATA REQUIRED

geographic limits
opposing strategies
orders of battle
operational data from scenario
tactical air and logistical resources

STRUCTURING THE THEATER OF OPERATIONS

air control authority
layout of sectors
ports of entry

ORGANIZATION FOR COMBAT

maneuver units
artillery support
close air support
inactive and reserve units
scenario phases
logistical considerations

SYSTEM RUN

immediate interpretations of situation
(perhaps return to PREGAME PREPARATION)

RESULTS

complete analysis*

* This analysis includes a comprehensive review of all inputs, parameters, and objectives. The run might be repeated several times in order to achieve satisfactory results. Throughout the above steps there is an implied recycle capability to ensure credible outputs from each previous step.

Figure 24. SUMMARY OF ATLAS RUN

The ATLAS model is actually composed of four different submodels (Figure 25): the tactical decision model; the logistics model; the tactical air model; and the ground combat model. These four sub-models are coordinated in such a way that each of them is involved in determining the movement of the Forward Edge of the Battle Area (FEBA), the model's decision variable which basically represents the point of contact between the two opposing forces. The involvement of each of these sub models in determining FEBA movement is indicated by the following assessment criteria [Ref. 19, p. 45]:

a) the firepower of each side after accounting for casualties and replacements

b) the days of supply available to the combat troops

c) the effects of aircraft assigned to close air support (CAS) missions

d) the nature of the terrain over which the fighting takes place.

e) the tactical posture of the combatants.

The FOREWON system, and particularly the ATLAS combat simulator, possess characteristics which may be desirable in the needs estimation process. They appear to be conceptually adaptable to the difficult task of comparatively assessing opposing forces in order to uncover "qualitative" deficiencies. Consequently, they will be evaluated more deeply in the following chapter of this study.

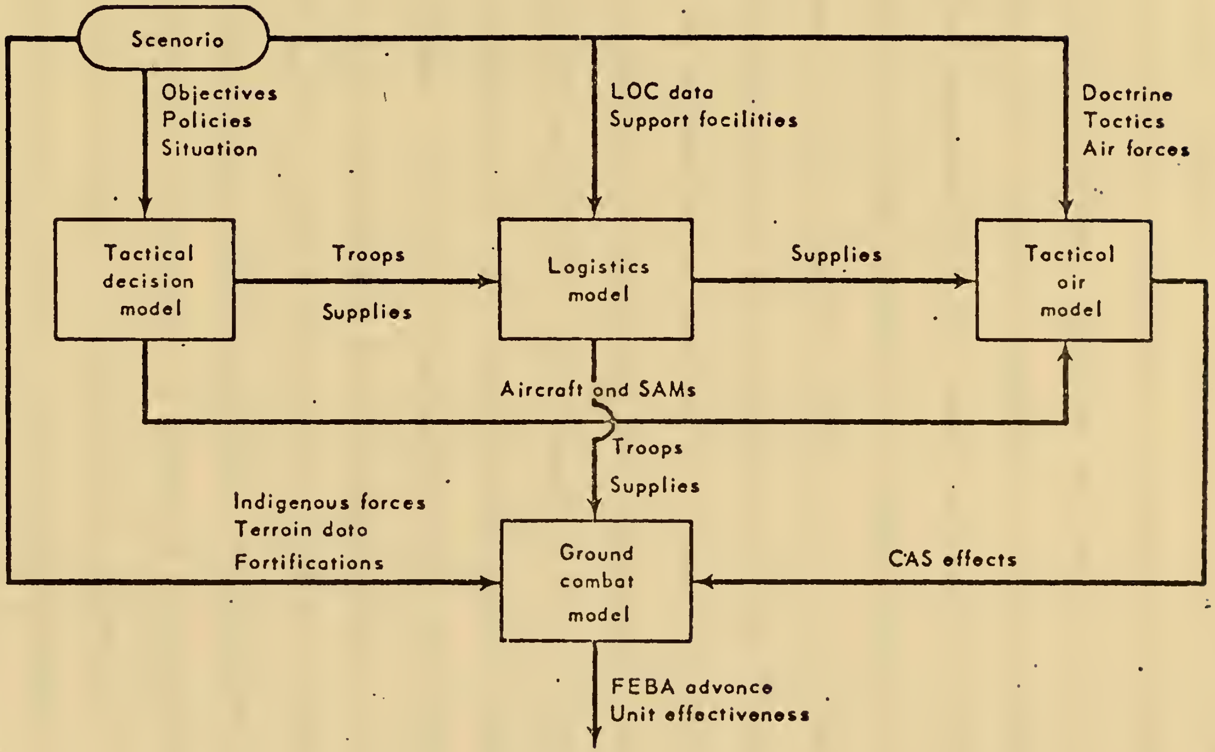

Figure 25. ATLAS FLOW CHART

IV. DEVELOPMENT OF A COMPOSITE PROCEDURE

A. INTRODUCTION

The second chapter of this study outlined the factors and processes which should be included in a thorough and comprehensive procedure for the estimation of future military needs. The third chapter presented several applicable methods for approaching the needs estimation problem, as illustrated by actual examples of their usage in this field. The purpose of this fourth chapter is to evaluate these various approaches in the framework of the conceptual model in order to determine a composite procedure which combines the most desirable aspects of the individual methods.

The first section of this chapter is devoted to a comparative analysis of the various approaches presented in Chapter Three. They are evaluated both in terms of their own particular advantages and disadvantages as separate needs estimation procedures and in terms of their interface with the conceptual model presented in Chapter Two (refer back to Figures 1 and 2 for a summary of the model).

The final section of the chapter attempts to combine the advantageous aspects of the individual methods into a coordinated approach which satisfies the requirements embodied in each section of the conceptual model. It concludes with an example of how this procedure might be applied in a hypothetical environment.

[illegible]

B. EVALUATION OF INDIVIDUAL METHODS

Each of the methods introduced in the previous chapter has its own peculiar advantages and disadvantages for application to the task of estimating needs. This section discusses the pertinent characteristics of these methods in order to determine their particular usefulness in the estimation of needs and their consequent applicability to the various components of this study's conceptual model.

The most readily apparent general attribute of the Threat/Response method is the fact that it is understood and accepted as the result of long usage. It is also a relatively simple and straightforward process to perform, since appropriate data on enemy capabilities and systems is fairly readily available from the intelligence community. As mentioned previously, a unique and valuable advantage of the particular variant of this method used in the Weapons TCP is that it is NOT scenario dependent. On the negative side, the Threat/Response methodology does not provide for consideration of the trade-offs between increases in numbers versus improvements in quality of weapons. It also does not address the importance of a particular threat in terms of overall national security. These considerations tend to promote "worst case" planning in which an attempt is made to counter all perceived threats individually and simultaneously.

In terms of the model, this method's treatment of capabilities is good, but objectives and strategies are ignored

and, as noted, environmental considerations are eliminated. It offers a crude but fairly simple comparative assessment process which is valuable in isolating strictly qualitative deficiencies in "one-on-one" type situations. Its conclusions, however, are often misleading since they do not consider quantity/quality trade-offs. Its provision for the evaluation of corrective concepts is oriented toward technical considerations exclusively and completely ignores important operational, strategic and political questions.

The Delphi method, as illustrated by A Study in Deterrence, contains several desirable characteristics for inclusion in a needs estimation procedure. It provides a comparatively "bias free" methodology for utilizing a consensus of expert opinion in the prediction and/or evaluation of difficult to quantify factors and considerations. It also provides results which are usually "reproducible," which is a definite advantage for a judgemental type technique. On the other hand, the quality of its results is highly dependent on the expertise of the selected respondents. Also, the device of controlled feedback constrains the free exchange of information which prevails in a face-to-face brain-storming session.

In terms of the model, this method appears generally well-suited for the prediction of the judgemental type inputs such as objectives, strategies, and the environments. It also shows promise in the evaluation of concepts for operational usability, technical feasibility, strategic tenability and political acceptability. Its main drawback in terms of

the model is that it offers no adequate method for the matching of capabilities to systems or the comparative assessment of opposing forces with subsequent identification of deficiencies.

The Relevance Tree methodology used in PATTERN is theoretically well adapted to the task of estimating needs due to its well defined hierarchical structure and provision for establishing the relative importance of alternatives. Specifically, it provides a systematic procedure for the identification and prioritization of particular technical deficiencies which threaten national security. This procedure, however, utilizes a numerical weighting methodology (as depicted in Figure 14) which implies an unrealistic degree of precision. Relevance numbers provide a valuable tool for ranking limited numbers of distinct alternatives, but it does not appear reasonable to assume that they can provide (as PATTERN suggests) a clearly defined ordering of priorities for 2000 different technical deficiencies.

In terms of the conceptual model, the relevance tree method offers an interesting structure for the specification of inputs but does not contain a well-defined process for <u>how</u> they should be specified. It also does not offer any means of conducting a comparative assessment of opposing forces or nontechnical evaluations of concepts. Its principal value for the model, therefore, lies in its well-defined hierarchical structure rather than its methodology for assigning relative priorities.

The Functional Network approach embodied in the MIRAGE studies is the only method analyzed which specifically addresses the complex relationships that exist between capabilities and systems. By delineating these relationships in a mission flow chart context, it illuminates the various strong and weak points in the capabilities of a given force structure. Unfortunately, however, meaningful flow charts are tremendously complicated and are, consequently, extremely difficult to construct and/or interpret.

In terms of the model, the MIRAGE procedure utilizes a detailed environmental analysis to determine probable "scenarios" and specify the various inputs. Deficiencies are isolated strictly through use of the mission flow charts and no explicit means of comparative assessment or nontechnical evaluation of concepts is included. Since all other characteristics of this approach are basically similar to those found in PATTERN, its primary unique value lies in the comprehensive environmental analysis which initiates it and the mission flow charts which relate capabilities and systems.

The Simulation method used in the FOREWON System is unique among the approaches examined because of its emphasis on comparative assessment of opposing forces in strictly quantitative terms. It also provides for an iterative analytic/evaluation process which can be used in determining the nature and extent of deficiencies. Because of its highly automated nature and consequent strict requirement for

quantified inputs, it entails the use of specific decision rules in order to eliminate the judgemental aspects of combat. Also, because it uses fairly crude techniques to analyze extremely complicated situations, it requires many simplifying assumptions in order to accommodate its relatively low degree of sophistication.

In terms of the model, the FOREWON approach uses standard military intelligence and planning guidance documents as a basis for the specification of the environments, objectives, strategies, and capabilities for the DGMTO. The comparative assessment and identification of deficiencies are jointly provided by the PFD and ATLAS model during a series of iterative operations. The analysts must manually alter the force structures between iterations in order to analyze the nature and extent of the identified deficiencies. No provision is currently included for the synthesis or evaluation of new concepts, but a procedure for the incorporation of this feature is currently under development [Ref. 20].

The primary value of the FOREWON approach in the context of this study is the fact that it effectively validates the structure of the conceptual model. While FOREWON and the model are significantly dissimilar in several respects, most of these dissimilarities can be directly attributed to the distinction between their respective purposes (i.e. mid-range force structure planning versus long-range needs estimation). It is in the areas most affected by this distinction, where qualitative/judgemental considerations are involved, that

other methods appear better suited to the needs estimation problem.

The foregoing discussion makes it readily apparent that, while each of the individual methods has its own peculiar advantageous characteristics, none of them is totally adequate to perform all of the processes contained in the conceptual model (see Figure 26). The next section, therefore, describes a composite approach which selectively combines these methods in order to exploit their respective benefits in a coordinated manner.

C. COORDINATION OF COMBINED METHODS

This section is concerned with the determination of a coordinated set of methods to be used in "operationalizing" the conceptual model. For the sake of clarity, it discusses the methods to be used for the various operations in accordance with the order in which these operations occur in the model (see Figure 27 for a summary). Before the methods themselves can be intelligently discussed, however, it is necessary to describe the structure in which they are combined.

The first consideration in the procedural development is the question of administration. Since it was stated in Chapter One that the approach should be structured in a mission-oriented context and should be systematic in nature, it should be administered by a group of experienced analysts who collectively possess a wide range of expertise in both operational and technical fields. The initial task of this

METHOD	SPECIFICATION OF INPUTS							ASSESSMENT ANALYSIS SYNTHESIS			ITERATIVE EVALUATION			
	Environment	Friendly Objectives	Enemy Objectives	Friendly Strategies	Enemey Strategies	Friendly Capabilities	Enemy Capabilities	Comparative Assessment	Deficiency Analysis	Concept Synthesis	Operational Usability	Technical Feasibility	Strategic Tenability	Political Acceptable
THREAT/RESPONSE	X	X	X	X	X	G	G	F	F	G	X	F	X	X
DELPHI	X	G	X	G	X	P	X	X	X	G	X	F	G	X
RELEVANCE TREE	X	G	X	X	X	G	X	F	F	G	X	G	X	X
FUNCTIONAL NETWORK	G	X	X	F	X	G	X	F	F	F	X	G	X	X
SIMULATION	F	F	F	F	F	F	F	G	G	X	X	X	X	X

KEY: G = Good F = Fair P = Poor X = None

Figure 26. COMPARATIVE SUMMARY OF INDIVIDUAL METHODS

PROCESS	PRODUCT	METHOD
Input Specification	Environment Objectives Strategies Capabilities	1. Environmental Analysis 2. Delphi Validation
Comparative Assessment	Friendly Deficiencies	1. Mission Flow Chart Conversions 2. Threat Analysis/ Simulation
Deficiency Analysis	Capability Weaknesses	1. Threat Analysis/ Simulation 2. Mission Flow Chart Conversions
Synthesis	Corrective Concepts	1. Brainstorming 2. Delphi Evaluations
Iterative Evaluation	Operationally Usable Concepts Technically Feasible Concepts Strategically Tenable Concepts Politically Acceptable Concepts	1. Delphi Evaluation

Figure 27. SUMMARY OF COMPOSITE APPROACH

group is the development of an imaginative and comprehensive environmental analysis (of the type used in MIRAGE) for the period 10-15 years in the future. This analysis is vitally important because it forms the basic framework for the remainder of the estimation procedure.

The environmental analysis is initially used as a foundation on which the analysts hypothesize relevant parameters (including alternative objectives, strategies, and capabilities for both opponents) for the probable conflict situations identified. These environments and associated parameters are then "validated" by a select group of civilian and military officials (from the State Department as well as all components of DoD) in one of three ways: informal oral discussion in a committee atmosphere; formal written commentary through the chain-of-command; use of the Delphi technique. Because of the difficulties traditionally encountered with the first two methods, Delphi is considered the most appropriate method for validation. The Panel's initial task in this Delphi is to evaluate the possible environments envisioned by the analysts, in order to validate their realism and likelihood. Next, the panel successively identifies in a cross-impact context the appropriate intersections of the listed objectives, strategies, and capabilities of the opposing forces in each of the environments. The overall result of this Delphi is the delineation of probable conflict environments for the period under consideration;

with the likely objectives, strategies, and capabilities of the opposing forces specified for each one.

Taking the information from the validation Delphi as input data, the four transformational processes of the model can be initiated. The first step in this section of the procedure is the development of mission flow charts with which to translate general capabilities to specific systems. By comparing the capability requirements provided by the Delphi process to the flow charts, the types of systems utilized by each opponent in a particular conflict situation can be determined. This data can then be coordinated with opposing strategies to form the input for the comparative assessment process.

If only an approximate and strictly qualitative delineation of deficiencies is needed, the Threat Analysis method can be used. If, however, quality/quantity tradeoff considerations are involved, the Simulation approach is appropriate. By selectively adjusting the parameters between successive simulations of a conflict environment, the identified deficiencies in the friendly force can be individually analyzed to determine their respective gravity and urgency. Those deficiencies which are not correctable by realistic increases in force levels are further analyzed through use of the mission flow charts to isolate the capabilities involved as a basis for the synthesis of corrective concepts. The synthesis process itself is best accomplished in a "brainstorming" context designed to produce a broad range of

concepts as insurance against the prevalent military tendency to concentrate on a single (preferred) alternative.

Once the initial set of concepts has been synthesized for the correction of a particular deficiency, the next step is to evaluate and refine it in order to "separate the wheat from the chaff" prior to the expenditure of time and money on R&D efforts. The four types of evaluations required are optimally performed by experts from the operational, technical, strategic, and political fields, respectively. They can be performed in any one of three different ways discussed for validation but also appear to be most appropriately accomplished by the Delphi process.

In order to identify and analyze the various trade-offs between them, all four types of evaluations should be made simultaneously. The selected experts are requested to evaluate, in the context of their own fields, the alternative concepts for correcting a particular deficiency and to recommend any other concepts which they may deem appropriate. After several iterations of interview and mutual feedback among the various specialists on the panel, a set of concepts is generated and evaluated which is considered viable under all four sets of criteria.

For purposes of clarification and illustration, the procedure described in this section may be displayed in the context of a three section relevance tree similar to the one used in PATTERN. In this case, the levels (in order) are environments, deficiencies, and concepts. If a ranking

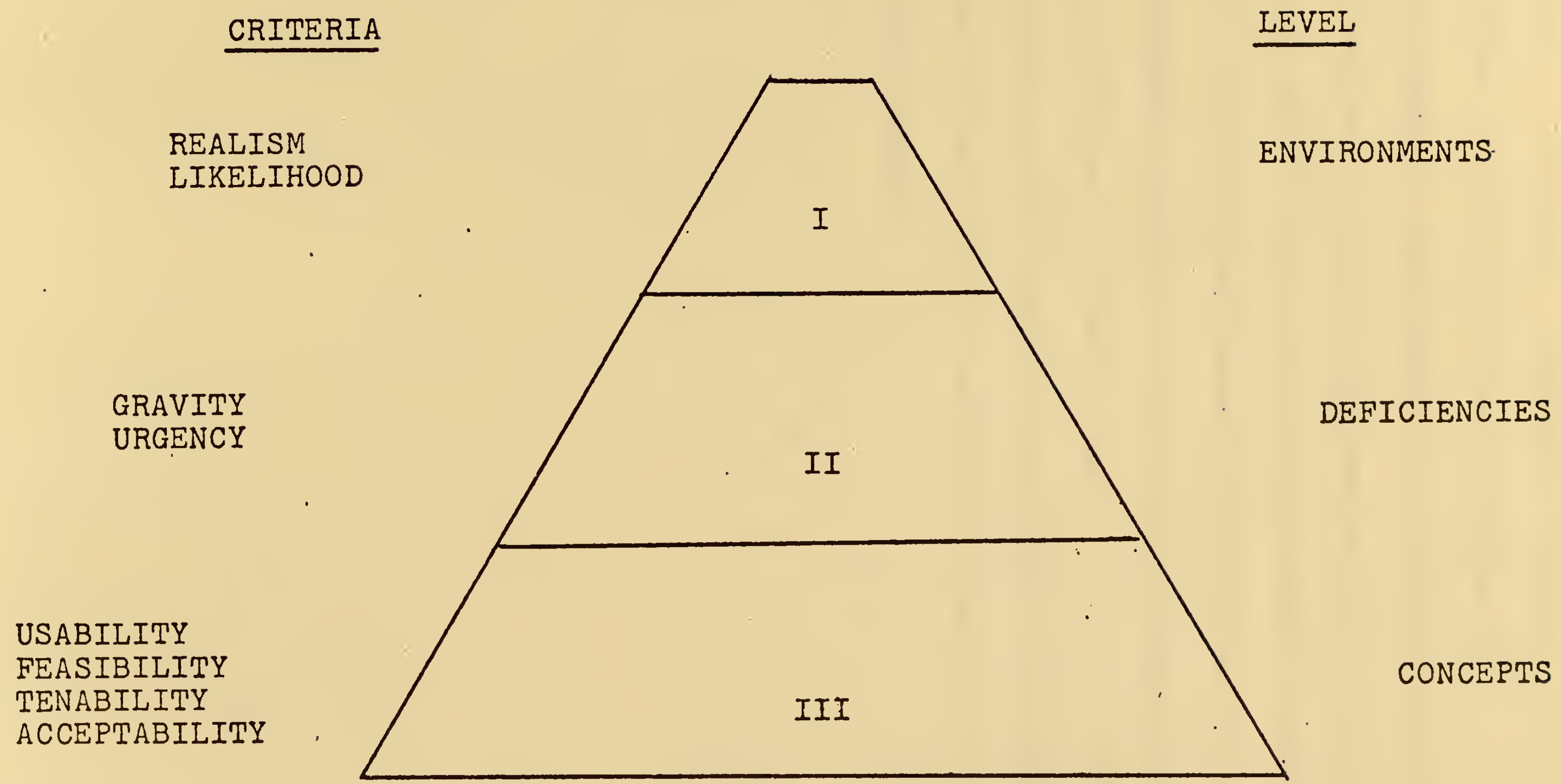

Figure 28. COMPOSITE RELEVANCE TREE

of the elements on any particular level of the tree is considered desirable, suggested criteria for this purpose are listed on the left side of Figure 28.

In summary, while none of the five methods discussed in this study are individually adequate for estimating future military needs, they can be selectively combined in order to provide a coordinated means of performing the several types of processes involved. The composite approach presented here is designed to "match the tool to the job" by combining those methods that appear most useful for managing the particular characteristics embodied in each section of the conceptual model.

V. CONCLUSIONS

A. SUMMARY OF ANALYSIS

The purpose of this paper, as stated in the introduction, was to systematically develop and analyze a generalized procedure for estimating future military needs as a basis for exploratory R&D planning. In the course of pursuing this goal, the study examined three different aspects of the needs estimation problem.

The first portion of the analysis described and analyzed the elements of the problem in the context of a conceptual model. The specification of the various inputs as well as the comparative assessment, analysis, synthesis, and iterative evaluation processes involved in transforming them into statements of need were discussed and illustrated. In addition, an example of the hypothetical operation of the model was presented.

The second portion of the analysis (Chapter Three) examined several distinctly different analytic methods by discussing approaches to needs estimation which have been founded on them.

Chapter Four dealt with a comparative evaluation of the various individual methods in terms of their applicability to needs estimation in general and to this study's conceptual model in particular. Since none of the individual methods appeared capable of adequately dealing with all aspects of the problem as delineated in the model, a composite approach

was developed to combine and coordinate several of their most beneficial characteristics. This approach is structured in an overall relevance tree framework and is designed to utilize Delphi and cross-impact techniques in the more subjective or judgementally oriented areas plus functional network analysis and threat assessment or simulation in the objective or easily quantifiable ones.

The procedure developed in this study provides a systematic methodology for the estimation of future military needs in an overall mission-oriented force structure context for use as the planning base for allocation of exploratory R&D assets. Its output consists of needs statements as described in Chapter Two which reflect not only projections of operational deficiencies, but also suggestions of corrective concepts which appear to merit investigation and exploitation.

B. SUGGESTED AREAS FOR FURTHER STUDY

This study has not explicitly addressed the tremendous difficulties involved in implementing the various methods suggested for use in the composite procedure. Therefore, an important area of further studies is the actual development of the processes required. References 21 and 22 indicate that while the problems associated with developing usable processes are by no means insurmountable, they are difficult and time-consuming.

Another equally important area for study involves the applicability of the proposed procedure for implementation

at the various cognizant levels of DoD. Since the included tasks must be performed within the existing bureaucratic structure, an investigation of the relevant interfaces in this structure would be extremely valuable. In the same vein, an in-depth analysis of actual DoD procedures in this area would be helpful in determining which of these procedures are most useful and how they might be improved and/or combined to more closely approximate the type of procedure proposed in this study. As stated previously, the author intends to examine this latter aspect of the problem in a related follow-on study which will investigate the existing needs estimation procedures within DoD and the manner in which they might be more effectively utilized.

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A systems analysis of the processes involved in the estimation of future military needs is presented. A conceptual model of the estimation procedure is formulated and illustrated. Several applicable methods are examined in the context of practical approaches to the needs estimation problem. These methods are then evaluated in the framework of the conceptual model. Finally,

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a coordinated procedure is developed which combines several of the most valuable characteristics in the individual methods.

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